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AUTHOR	Friedman, Richard B.; And Others
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ABSTRACT

For the past five years a group of doctors at the University of Wisconsin has been developing a realistic computer-based simulation of the patient-physician encounter. Utilizing the time-shared computers, large memory and high speed logic, they have developed a highly sophisticated program which permits the physician to work-up and diagnose patients in the in-patient and out-patient environment. This program has been tested in over 1,000 simulated encounters and is currently operational at a number of medical centers around the country. Criteria for standard evaluations have been developed and tested. The main drawback is that the physician must communicate with the computer via a relatively expensive computer terminal. In order to overcome the necessity of using expensive computer terminals they propose to combine their fully operational simulator with a Voice-Response System. Combining these two systems would permit a physician to take a simulated encounter using any standard telephone (touch-tone or dial). The physician would communicate with the computer by dialing in the necessary test request, diagnosis, etc. The computer would communicate with the physician through easily understood verbal responses. This interaction could take place anywhere there is a telephone and literally thousands of encounters would be possible simultaneously. (MV)

November 10, 1976

FINAL REPORT FOR VOICE RESPONSE SYSTEM PROJECT

ON

COMPUTER EVALUATION OF CLINICAL COMPETENCE

FOR THE

NATIONAL FUND FOR MEDICAL EDUCATION

Principal Investigator

Richard B. Friedman, M. D.
Dept. of Medicine & Human Oncology
Univ. of Wisconsin - Madison

*Collaborators

Dr. Donald R. Korst
Dr. Sigurd E. Sivertson

Contributors

Hardware

Sunming Cheung

Analysis

James V. Schultz, Ph.D.
Judith Neal
Robert S. Newson, Ph.D.

Programming

Steven M. Entine

Testing

Marilynn Jenkins
Elaine McDonald
Thomas C. Meyers, M.D.
Richard Hansen

Demonstrations

Shelley Hirshberg

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Purposes

A computerized voice response system has been developed and tested during the past year involving groups of medical students, medical residents and practicing physicians. Three general purposes were established for the project. They were:

1) to develop a prototype computerized voice system adapted to the needs of continuing medical education

2) to field test the system using volunteer-practicing physicians and student physicians

3) to provide evidence that a computerized voice is a sound method of communication which can assist in a medical self-evaluation education program.

The Voice System

The value of a computerized voice system is to extend computer usage via presently-existing and/or inexpensive technology. A major limitation of computer applications has been the requirement of a direct link to the computer via expensive terminal equipment. This usually requires either direct interface of monitoring equipment with expensive modems and cables or use of either 'hard wired' or 'acoustically' coupled computer terminals. (Most medical applications have utilized computer terminals connected to the main computer by acoustic couplers.) These terminals cost between $1,500 and $10,000 each and require the user to be in a specific location, i.e., reducing accessibility, and to be able to use a keyboard, i.e., reducing versatility.

Presently, voice system users require only a telephone and are provided with a touchtone pad, amplifier and instruction manual. Physician-users communicate with the computer with a standard telephone (touchtone or dial), dialing the necessary test, request, diagnoses, etc. This computer interaction can take place anywhere there is access to a telephone and is not dependent upon familiarity with a terminal keyboard.

The system itself consists of a large and a small computer, a Votrax Voice generating unit and a TEAC tape recorder. A diagram illustrating the system can be found in Appendix 1. Following, (see Appendix 2), is a diagram showing the appropriate set-up of this equipment. A copy of the user instruction manual has been included with this report.

A. Hardware

The following is a description of the system. A voice generating unit which is a commercially developed Votrax synthesizing unit is connected to a small computer (PDP-8) and together they produce a simulation of the human brain-vocal system. That is, under program control, the computer (brain)

and voice synthesizer create the spoken English words.[1] These words are formed using a computer terminal and each must be made individually using any combination of the available phonemes. The Votrax unit is capable of producing 64 phonemes. The voice system vocabulary now consists of some 3,500 words. The words are stored on the large computer (PDP-15). The voice system uses a terminal that is either a touchtone telephone or a touchtone pad which can be attached to a standard dial telephone.

The system itself was put together and is maintained by an electrical engineer. All programming was done in MIIS (MIIS is a programmer language which is a dialect of MUMPS) by a computer programmer. Several students were hired on a part-time basis to build the words over the past year. Great pains were taken to work and rework each word until it sounded satisfactory. All the work was done between June of 1975 and June of 1976, with the exception of a limited amount of vocabulary building and preliminary design of the system. The voice system can be used anywhere in the country.

B. Software

The voice system is designed to simulate the patient-physician encounter. Five scripts are available on the system and each script involves a patient disorder for which a physician should do a work-up and arrive at a correct diagnosis. Below is a brief description of each script along with the correct diagnosis:

SCRIPT	CASE #	CORRECT DIAGNOSIS
- A 92-year-old man with weakness, chills and fever.	6	Waldenstrom's macroglubulinemia
- A 33-year-old man with a possible myocardial infarction.	9	Normal patient
- A 64-year-old man with cough and weight loss.	10	Tuberculosis
- A 43-year-old man brought to the hospital after collapsing.	13	Aortic aneurysm
- A 36-year-old female with persistent back pain.	15	Lupus erythematosus

There are 368 tests which may be ordered; and results are returned as they would be in a real hospital situation. When a test is ordered, the physician is automatically charged for it and at the conclusion of the work-up, all expenses are totaled and the user is presented with a bill. The physician chooses a script, is presented with a patient complaint, orders tests, receives results and makes a diagnosis. All tests and diagnoses are

[1] The system not only produces synthesized voice but is also capable of using natural voic[illegible]nterfacing a TEAC tape recorder with the system. An application using the "natural" voice is described at the end of this report.

coded; and all input is achieved by pressing the touchtone keys.

C. Parameters of Evaluation

At the conclusion of the work-up the user is given the opportunity to have his/her work-up evaluated. Four of the scripts include evaluative measures utilizing a model developed by the Medical Education Group at the Univ. of Illinois. This model uses a scoring system ranging from +3 to -3. Using these parameters, the voice project evaluation committee assigned each test for a particular script a value within the +3 to -3 range. Thus, tests which were considered necessary to perform ranged toward the positive end of the scale while tests which were important to avoid ranged toward the negative pole of the scale:

+3 essential to do
+2 important to do
+1 helpful
0 optional
-1 useless
-2 harmful
-3 essential to avoid

Scores of efficiency, proficiency, errors of omission, errors of commission and a competence index were calculated from these values using the following formulas:

$$\text{Efficiency} = \frac{\text{number of positive items selected}}{\text{total number of items selected}}$$

$$\text{Proficiency} = \frac{\text{weighted (algebraic) sum of items selected}}{\text{maximum possible score}}$$

$$\text{Errors of omission} = \frac{\text{weighted sum of positive items not selected}}{\text{maximum possible score}}$$

$$\text{Errors of commission} = \frac{\text{weighted sum of negative items selected}}{\text{maximum possible score}}$$

Competence index = combined function of efficiency and proficiency

Since no physician would be expected to order every test with a positive value, no participant would be expected to obtain a perfect (100) score. For each case a competence index between 30 and 40 was projected as normal and a score of above 40, superior. A competence index above 60 would, in most cases, occur only if one undertook an excessively complete work-up.

At the end of the scripts, the computer asks if one wishes to have the work-up evaluated. A 'yes' response gives the following information:

Efficiency	Number of days in hospital
Proficiency	Cost of diagnostic work-up
Errors of Omission	Cost of hospital room ($90/day)
Errors of Commission	Total cost of hospitalization
Competence Index	

All data is stored in the computer and can be retrieved at any time. This data includes the length of time the user was on the system, tests ordered, times results were given, correct or incorrect diagnosis and user's scores. An example of the data output summary can be found in Appendix 3.

D. Chronology of Events

During the initial period of the project, from July 1975 to December 1975, the work centered on transferring the simulation encounter program from the Univac 1110 computer to the PDP-15. In addition, the Votrax voice synthesizing unit was obtained and made operational by interfacing it with a PDP-8 computer. Finally, the process of building the necessary dictionary words and retrieve the words from the PDP-15 as part of the simulated patient-physician encounter was carried out during this period.

In January, 1976, the Department of Continuing Medical Education at the University of Wisconsin was contacted to coordinate practicing-physician use of the simulation encounter. Physicians from around the state were contacted and sent equipment (touchtone pad, amplifier, and instruction manual) so they could participate in the study. At the same time, extensive system testing and debugging was carried out by the project personnel.

Beginning in March, 1976 the testing of the Voice System was carried out. Although the system had responded well when tested by project personnel, the variations in the quality of phone lines around the state caused numerous difficulties. After extensive debugging and experimentation with alternatives (e.g., hooking the touchtone pad to the phone via connecting wires and clips), the system still did not respond very consistently. For example, over 50 physicians were sent equipment, yet less than half of these were able to get connected to the voice system and work-up one or more cases. The results indicated that although the technology for a voice system is adequate, the necessary phone line technology is not yet existent on a statewide basis.

Field Testing

A. Student Physicians

The system became operational in February of 1976. At that time volunteers were solicited to test the system. These volunteers consisted of third year medical students and first, second and third year medical residents at the University of Wisconsin Medical Center. They were asked to spend from three to four hours testing the system. They identified "bugs" in the system which were then corrected. The students were provided with testing units where each unit consisted of a touchtone pad, instructional manual and amplifier. The amplifier eliminated the necessity of holding the telephone to the ear, thus, the individual enjoyed free use of his hands for note taking during the work-up. The students were compensated for their assistance with a medical text.

B. Practicing Physicians

Meanwhile, the Postgraduate Education Department (PED) at the University of Wisconsin Medical Center solicited volunteer practicing physicians from throughout the state to test the system. This group deals with physicians

throughout the state on a continuing medical education basis, hence, their recruiting ability was of great value to us. An agreement with PED to arrange for testing was made when this project was conceived. They were contracted to recruit physicians, to arrange testing and to distribute the necessary equipment. Contact with the physicians was made primarily by mail, along with announcements over an educational telephone network.

In the first part of April, the PED was provided with ten testing units. Fifty physicians had been recruited. For participating in the study, the physicians were offered the choice of a medical text or an honorarium. PED asked these physicians to spend a minimum of two hours working with the system in an effort to complete as many of the five scripts as possible. Many spent more than two hours. To insure anonymity, each user was assigned a number by PED; hence, all data was stored in the computer under a number rather than a name.

Most physicians were not within the Madison area code, and therefore, a long distance call was necessary. The physicians called the University of Wisconsin Centrex operator on the Watts line and were then connected to the computer. This made the calls inexpensive and in addition the doctors were not billed for telephone usage.

C. Testing Difficulties

Throughout the course of testing, mechanical difficulties were a constant problem. Users would order tests and ones different from those that were ordered would be returned. At times the program would stop in mid-script requiring the user to begin the case anew. It was discovered through extensive testing that the source of these difficulties was either in the telephone or the touchtone pad or a combination of the two. At times the touchtone pads did not send out sufficiently sharp frequencies, so that test order confusion resulted. Also, some telephone lines did not consistently relay the touchtone signals, even when there were sufficient frequencies.

These difficulties were thus dependent upon touchtone quality and upon location of the telephone being used. The problems were transient and unpredictable in terms of establishing a priori which locations would provide suitable phone line transmission, or identifying a faulty touchtone pad.

No problems were encountered when working with the system using a touchtone telephone. Unfortunately, most of the physicians did not have touchtone phones.

Findings

A. Affective Dimension - Student Physicians

Upon completion of their work-ups, student physicians were asked to complete a questionnaire aimed at measuring reactions to the voice computer. The following questions were asked:

Were you able to understand the speech?

Did you find this problem-solving exercise realistic?

Do you feel this is a reasonable method of communication?

Do you feel this could serve a continuing education function?

Do you feel this is an effective means of self-evaluation?

Did you encounter mechanical difficulty?

Did you enjoy working with the system?

Since the sample group of users was small in each case (7 3rd-year medical students and 14 medical residents), it was not germane to perform a statistical analysis of the responses to these questions. However, the responses indicated that none of the students experienced difficulty in understanding the computer speech. Answers to other questions provided less than unanimous results:

Student Physician Questionnaire Results*

	*WL	yes	no
Were you able to understand the speech?	0	21	0
Did you find this problem-solving exercise realistic?	6	8	7
Do you feel this is a reasonable method of communication?	2	18	1
Do you feel this could serve a continuing education function?	0	16	5
Do you feel this is an effective means of self-evaluation?	7	10	4
Did you encounter mechanical difficulties?	0	16	5
Did you enjoy working with the system?	0	12	3

WL = within limits (responses that were somewhere between a definite yes or no)

It is, for example, somewhat ambiguous as to whether users felt the system to be a realistic experience in problem solving; a majority of users agreed that it was realistic, but expressed reservations because the system concentrated on laboratory diagnosis and did not allow patient management nor did it allow for a sense of the patient. A majority judged it to be a reasonable means of communication, while a smaller and opposed majority agreed it could serve a continuing medical education function. Users were guarded in their opinion that the voice system offers an effective means of self-evaluation. Several expressed the opinion that it left out patient-physician interaction; some did not agree with the evaluation; others suggested that it measured how well one "played the game." A number of users encountered mechanical difficulty, but most agreed that the system itself was enjoyable to use.

*A breakdown by year-of-training of these questionnaire results is given in Appendix 4, Table One.

B. Affective Dimension - Practicing Physicians

Upon completion of the work-up the practicing physicians were also asked to complete a questionnaire on their reactions to the voice computer. The following questions were asked:

Did the problems closely approximate real life, (i.e., were they realistic?)

Did you learn something from the simulated problems, (i.e., is this a good self-evaluation method?)

Do you know more about your strengths and weaknesses, (i.e., is this a good self-evaluation method?)

Did you enjoy working through the patient problems?

Did you encounter mechanical or technical difficulties?

Were the instructions easy to follow?

How would you rate the understandability of the voice:
Excellent___Good___Acceptable___Bad___Unacceptable___

Practicing Physician Questionnaire Results

	*WL	yes	no
Did the problems closely approximate real life?	-	19	1
Did you learn something from the simulated problems?	4	15	2
Do you know more about your strengths and weaknesses?	1	14	5
Did you enjoy working through the patient problems?	-	20	2
Did you encounter mechanical or technical difficulties?	1	19	20
Were the instructions easy to follow?	4	15	3

Ratings on the Understandability of the Voice

Excellent	-
Good	3
Acceptable	16
Bad	3
Unacceptable	1

*WL = within limits (responses that were somewhere between a definite yes or no)

9 out of 30 practicing physicians returning questionnaires were unable to get on the Voice Response due to telephone connection difficulties.

The results indicate that although the majority of practicing physicians experienced some form of difficulty in using the Voice Response system this same large majority enjoyed working with the system and felt they learned something from using it. All in all the responses indicate a generally positive attitude by the practicing physician towards using the voice system and in terms of their ability to understand the actual voice.

C. Voice Response Results

For each script used by a physician, data on the time spent per case, on the cost of the work-up (including both hospital charges and charges for tests orderd) and on whether a correct diagnosis was obtained, was collected. In addition, for those four scripts (6, 9, 10 and 15) that had the scoring system of essential to nonessential tests, data on the efficiency, proficiency, errors of omission, errors of commission, and competency index-scores were collected. Tables One, Two, and Three summarize the data.

These tables contain the means, standard deviations, and n's for each of the parameter scores for each case as well as the combined total for all cases. Table One presents the data for the medical students, Table Two for the resident physicians, and Table Three for the practicing physicians.

The data in these tables generally indicate no particular differences or trends due to level of experience; that is, practicing physicians do not consistently score more positively on the parameters of evaluation than either the resident physicians or medical students. This however is most probably due to the content level of the scripts and the nature of the simulation encounter. None of the scripts and associated tests require any degree of knowledge specialization that comes with greater medical training and/or experience. Further, the simulation encounter does not require extensive patient management skills of directing and modifying therapeutic interventions on the basis of patient response. Rather it concentrates on obtaining and interpreting diagnostic data for which it could be assumed all three levels of physicians are proficient.

Interestingly, one parameter, the overall diagnostic rate (i.e., the mean correct diagnosis by physician level for all patient cases tested) goes down for the practicing physician. The rates are 77%, 79% and 61% for medical students, resident physicians and practicing physicians, respectively. This proposition could be empirically substantiated through testing for therapeutic intervention parameters on these three subgroups. Such a feature is provided in a study presently underway.

To summarize the data in Tables One, Two and Three (i.e., see Table Four) the threes parameters of a) time spent on a case, b) total cost including both work-up and hospital charges, and c) competency index rating were considered. It was felt that these parameters, in addition to the Correct/Incorrect diagnosis variable, best measured differing aspects of the simulation. Since Case 13 did not contain the expected analysis of the tests (i.e., efficiency to competency-index scores) it was not included in this summary. Also, in some instances mechanical difficulties led to incomplete work-up of cases which did not include these scoring parameters. Consequently, the number of subjects for this summary is 20, 29 and 36 for the medical students, the resident physicians, and the practicing physicians, respectively.

Table Four presents the means, standard deviations and N's for the summarization using the parameters of time, cost and competency index for each physician level tested. In this summary the level of physician training (e.g., medical students vs. residents and/or practicing physician) does show percentage increases for all three measurements of time, cost and competency index. For example, considering the time parameters on medical student to resident and medical student to practicing physician, the percentage increases are 19% and 16% respectively. On the cost measurement the percentage increases are 16% and 44% respectively and for competency-index measurement the percentage increases are 16% and 13%. Thus, it appears that the experienced (e.g., residents and practicing) physicians are providing the simulated patients with more extensive work-ups and taking more time to reach a diagnosis than the medical students while gaining somewhat higher competency index scores in the process.

Finally, there appear to be very small differences between the residents and the practicing physicians on the time and competency-index measurements; only a 2% decrease for each from resident to practicing physician. However, the cost measurement shows an increase of 25%. Thus, percentage differences between residents and practicing physician groups appear minimal for all but cost measurement.

It should be noted the empirical results of these simulated patient-physician encounters are primarily of a pilot study feasibility nature and further, more controlled experimental investigations are required. However, the results of the continuing computer simulated instructional and evaluation effort lend support to the growing medical interest in individualized instruction via the computer and also offer potential for instructional innovation in other areas through the voice system approach.

It appears the Voice-Response System is an adequate means for obtaining performance data on the ability of physicians to obtain and interpret diagnostic data. The affective data indicates the viability of the voice technology as a means of enhancing physician skills. Certainly as the technology, both in the quality of the voice and the consistency of phone line transmission improves there appears to be preliminary evidence that such a voice system can become widespread.

The simulated encounter does provide clear, safe and measurable alternatives to a "real-life" behavioral learning/practicing situation where the safety, integrity or future repercussions of physician error caused by independent actions might be uncontrollable or irreversible. Similar comput assisted encounters in such areas as "Psychologist-client" or "Teacher-Pupil" may prove to be of great future help in the areas of initial instruction, on-going evaluation, and periodic review by either learner or teachers.

VOICE
MEDICAL STUDENTS

TABLE ONE

$\overline{X}$ - Average
N - Number
SD - Standard Deviation

	CASE 6	N	9	N	10	N	13	N	15	N	TOTAL	N
Time	75.02		36.11		24.25		36.56		39.04		44.37	
(minutes)	22.97	7	14.19	5	12.36	6	6.78	4	8.27	4	24.32	26
Workup Cost	729.63		370.35		241.58		1619.75		704.88		681.04	
(dollars)	358.20	7	130.05	5	66.27	6	783.60	4	150.26	4	564.06	26
Hospital Cost	887.14		288.00		150.00		360.00		517.50		463.85	
(dollars)	210.61	7	133.49	5	109.00	6	127.28	4	236.70	4	326.68	26
Diagnosis	.43		1.0		1.0		.50		1.0		.77	
(% correct)	.53	3		5		6	.58	4		4	.43	22
Efficiency	44.20		57.00		65.17				64.75		57.80	
	8.67	5	10.17	5	10.53	6			13.84	4	13.16	20
Proficiency	34.00		57.60		48.50				38.25		45.10	
	9.38	5	17.33	5	10.37	6			8.62	4	14.45	20
Errors of Omission	57.40		31.00		48.17				56.75		47.90	
	9.91	5	14.30	5	9.41	6			5.12		14.37	20
Errors of Commission	7.20		10.20		2.33				4.00		5.85	
	4.79		9.96	5	2.34	6			4.24	4	5.99	20
Competency Index	15.72		34.37		32.48				25.50		27.37	
	6.30	5	15.67	5	10.68	6			9.90		12.77	20

VOICE RESIDENTS

TABLE TWO $\overline{X}$ - Average N - Number SD - Standard Deviation

	CASE 6		9		10		13		15		TOTAL	
Time (minutes)	82.93 27.35	7	36.87 16.76	10	35.28 26.003	8	54.71 28.06	6	46.49 11.83	8	49.53 27.11	39
Workup Cost (dollars)	1129.70 771.54	7	667.54 695.89	10	473.69 410.94	8	2345.67 960.51	6	602.68 131.35	8	955.60 878.63	39
Hospital Cost (dollars)	1092.86 451.28	7	342.00 92.95	10	180.00 127.28	8	405.00 158.46	6	393.75 220.13	8	463.85 380.46	39
Diagnosis (% correct)	.43 .53	7	.90	10	.875 .35	8	.83 .41	6	.875 .35	8	.795 .409	39
Efficiency	50.83 12.91	6	57.56 18.81	9	68.14 12.56	7			65.14 4.18	7	60.55 14.53	29
Proficiency	54.17 12.38	6	47.33 10.58	9	54.86 12.03	7			49.71 6.68	7	51.14 10.51	29
Errors of Omission	37.83 9.81	6	37.89 13.31	9	36.14 6.67	7			44.00 7.46	7	38.93 9.91	29
Errors of Commission	7.33 6.02	6	13.89 10.15	9	8.14 9.56	7			4.86 2.67	7	8.97 8.36	29
Competency Index	28.42 12.34	6	27.86 12.20	9	38.20 13.24	7			32.70 5.22	7	31.64 11.44	29

VOICE
PRACTICING
PHYSICIANS

TABLE THREE — $\bar{X}$ - Average N - Number SD - Standard Deviation

CAS

	6		9		10		13	15		TOTAL	
Time (minutes)	87.55 50.03	9	38.47 14.79	10	29.55 12.75	11		38.29 10.93	6	47.99 35.26	36
Workup Cost (dollars)	2048.89 2752.15	9	344.85 187.23	10	379.86 215.42	11		927.86 451.75		878.73 1514.88	36
Hospital Cost (dollars)	1000.00 222.49	9	342.00 125.86	10	180.00 113.84	11		810.00 98.59	6	535.00 373.22	36
Diagnosis (% correct)	.33 .500	9	.800 .42	10	.909 .301	11		.166 .408	6	.611 .494	36
Efficiency	56.22 16.14	9	71.800 17.94	10	70.909 13.43	11		54.50 16.56	6	64.75 17.20	36
Proficiency	37.89 16.18	9	54.00 13.43	10	54.64 11.42	11		26.17 10.98	6	45.53 16.93	36
Errors of Omission	54.89 13.65	9	39.50 14.29	10	39.909 11.26	11		67.33 10.33	6	48.11 16.25	36
Errors of Commission	6.22 9.19	9	5.80 5.51	10	4.18 3.95	11		5.33 4.76	6	5.33 5.96	36
Competency Index	22.10 12.43	9	39.095 15.43	10	39.45 11.499	11		15.09 9.15	6	30.95 15.85	36

TABLE FOUR

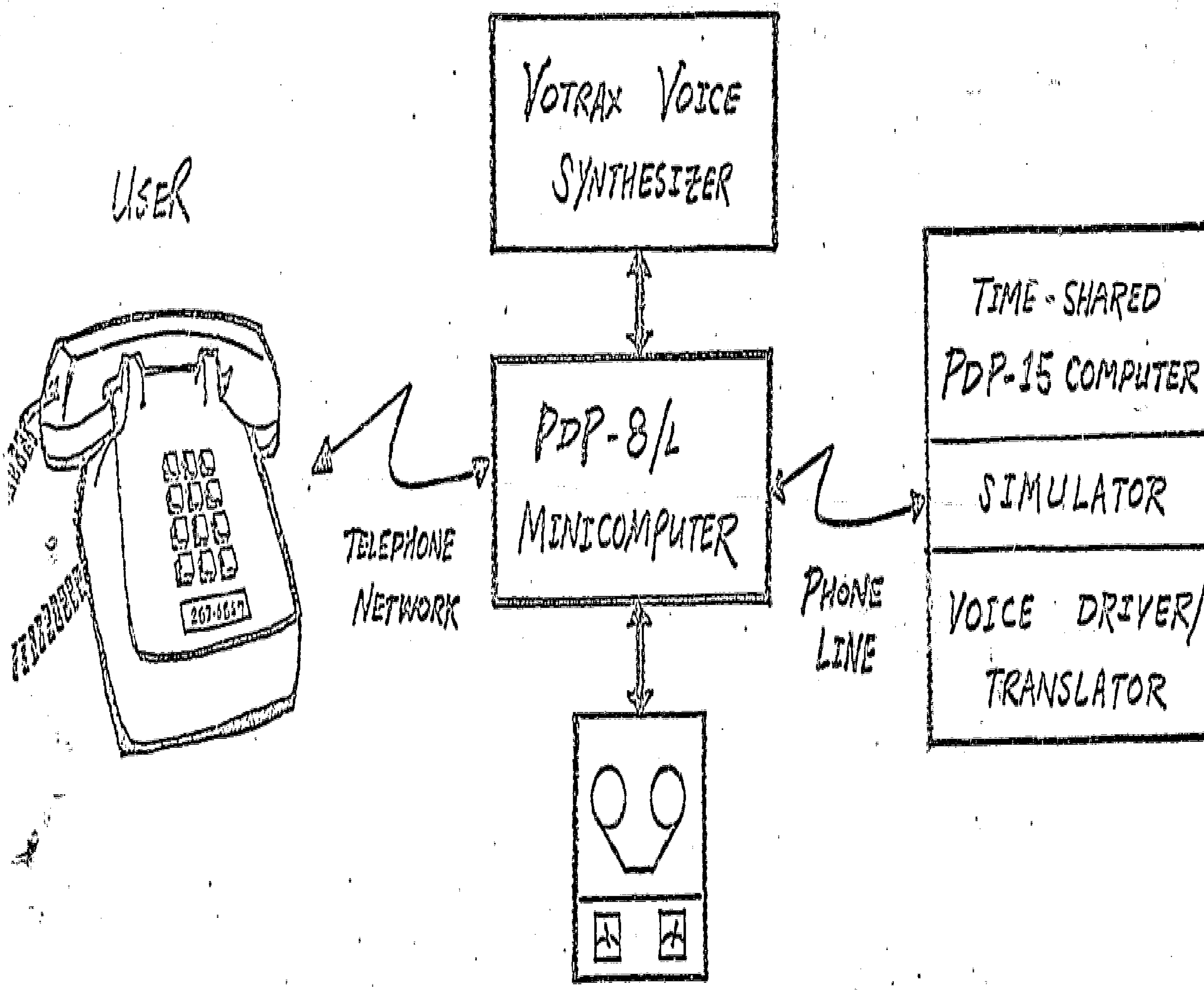
Summary Rate for the Voice Response System(for cases 6-15)

	N	Time		Cost		CI	
		$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD
Medical Students	20	41.26	22.54	975.98	645.00	27.37	12.77
Residents	29	49.18	27.77	1130.01	886.00	31.64	11.44
Practicing Physicians	36	47.99	35.26	1413.73	1724.00	30.95	15.85

APPENDICES

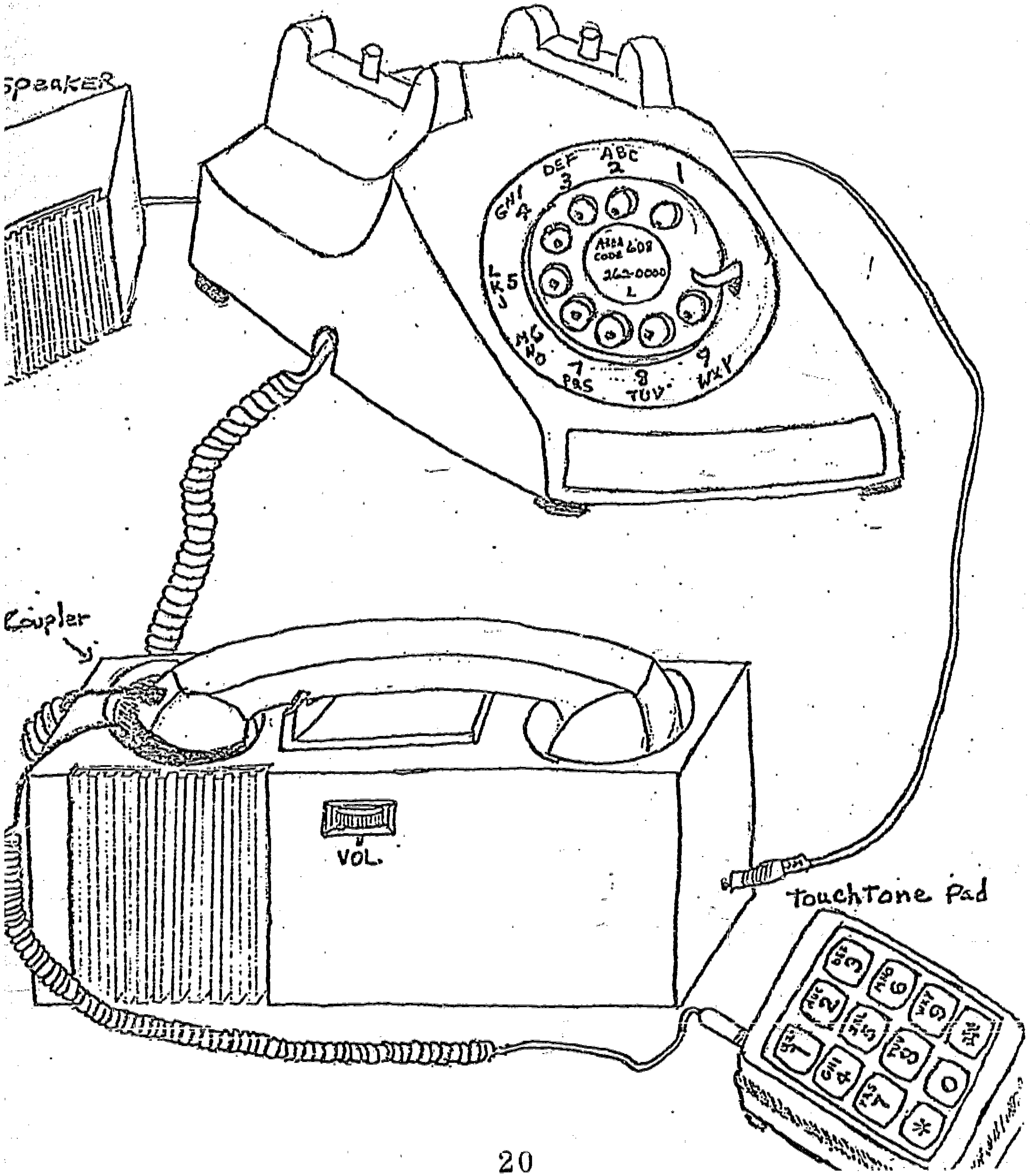
VOICE RESPONSE SYSTEM

Appendix 1



Basic Configuration of Voice System

APPENDIX 2 PROPER SETUP FOR TOUCHTONE PAD AND AMPLIFIER



APPENDIX 3: Sample Data Summary

```
***************************************************************
                    RECORD 255                    SCRIPT NUMBER 9009
                    USER: 20                      RUN DATE: APR 28 1976
USER BEGAN AT 7:07 PM AND ENDED AT 7:43 PM FOR AN ELAPSED TIME OF 0:36:34
COSTS:    WORKUP:                         $    560.00
          DAYS IN HOSPITAL:   5
          HOSPITALIZATION @ $90/DAY            450.00
          TOTAL:                          $   1010.00
CORRECT DIAGNOSIS: YES
EVALUATION:        YES
```

TEST OR DX		TIME TEST OR TX ORDERED	TIME RESULT RECEIVED OR DX MADE	
HISTORY	10	DAY 1 12:00	DAY 1 12:12	
PHYSICAL EXAMINATION	13	DAY 1 12:00	DAY 1 12:36	
STAT COMPLETE BLOOD COUNT	1224	DAY 1 12:00	DAY 1 12:30	
STAT WHITE BLOOD CELL DIFFERENTIAL	1257	DAY 1 12:00	DAY 1 13:00	
STAT ELECTROCARDIOGRAM	1036	DAY 1 12:00	DAY 1 12:12	
STAT CHEST X-RAY	1061	DAY 1 12:00	DAY 1 12:30	
STAT CREATINE PHOSPHOKINASE	1284	DAY 1 12:00	DAY 1 14:00	
SMA12	309	DAY 1 12:00	DAY 3 17:00	
STAT URINE ANALYSIS	1166	DAY 1 12:00	DAY 1 12:30	
STAT ELECTROLYTES	1290	DAY 1 12:00	DAY 1 12:30	
ARTERIAL BLOOD GASES	268	DAY 1 12:00	DAY 1 17:00	
STAT FLATPLATE OF ABDOMEN	1067	DAY 1 12:00	DAY 1 12:30	
STAT LUNG SCAN	1087	DAY 1 12:36	DAY 1 13:36	
LUPUS ERYTHEMATOSUS PREPARATION	212	DAY 1 12:36	DAY 3 17:00	
GASTROINTESTINAL SERIES	63	DAY 1 13:00	DAY 2 14:00	
ERYTHROCYTE SEDIMENTATION RATE	228	DAY 1 13:00	DAY 2 17:00	
SURGICAL CONSULTATION	117	DAY 1 13:00	DAY 1 14:00	
TRIGLYCERIDES	339	DAY 1 13:00	DAY 5 17:00	
BIOPSY	20	DAY 2 14:00	DAY 4 08:00	
SERUM IMMUNOELECTROPHORESIS	296	DAY 3 17:00	DAY 5 17:00	
****	6000	* * *	DAY 5 08:00	CORR

EFFICIENCY	45
PROFICIENCY	43
ERRORS OF OMMISSION	30
ERRORS OF COMMISSION	26
COMPETENCY INDEX	19.35

APPENDIX 4:

Replies received from 7 third-year medical students and 14 medical residents tested. (Medical residents have been broken down into first, second and third year.)

	3rd yr. Med			1st yr. Res.			2nd yr. Res.			3rd yr. Res.		
	*w/l	yes	no	w/l	yes	no	w/l	yes	no	w/l	yes	no
Were you able to understand the speech?	0	7	0	0	5	0	0	6	0	0	3	0
Did you find this problem-solving exercise realistic?	2	5	0	1	2	2	2	1	3	1	0	2
Do you feel this is a reasonable method of communication?	0	7	0	0	4	1	1	5	0	1	2	0
Do you feel this could serve a continuing education function?	0	7	0	0	4	1	0	4	2	0	1	2
Do you feel this is an effective means of self-evaluation?	4	3	0	0	3	2	1	4	1	2	0	1
Did you encounter mechanical difficulty?	0	5	2	0	3	2	0	5	1	0	3	0
Did you enjoy working with the system?	0	1	0	0	4	1	0	6	0	0	1	2

*w/l = within limits

APPENDIX V

VOICE SOFTWARE DOCUMENTATION

Votrax Synthetic Voice Response on PDP-15 System

January 16, 1976

General Design and List of Routines

The program for voice response on the PDP-15 consists of four routines used to speak English and numeric data. These are all called by one common entry point and will convert English text to spoken output. For faster access when the construction of the output is known in advance, string of pointers to the global nodes may replace English words.

In addition to these four major routines there are nine utility routines. These are used for building the dictionary, finding words in the dictionary, deleting words, transferring words, and listing the entire contents of the dictionary.

The major programs are as follows:

1) VSP - driver program for speaking subroutines

2) VOZ - speak text output or pointer output

3) VON - speak numeric output or time output

4) VSS - repeat last spoken output

The utility programs are:

1) VAM - move a word into an additional or alternate spelling

2) VAN - remove a word from the dictionary

3) CVZ - dictionary program for use with PDP-8 dictionary routine to allow entering and editing of dictionary

4) VAC - find a word in the dictionary and give phonemes and octal equivalent for the English

5) VAD - utility program used by VAC and CVZ to locate words in global

6) VLR - transfer words from dictionary into global CW for sorting and printing

7) VLT - Delete duplicates from list of "needed" dictionary words

8) VLO - list all words in dictionary

9) VLQ - list all words not found in the dictionary which appeared in text to be spoken

Votrax Synthetic Voice Response on PDP-15 System

TITLE: VSP

PURPOSE: Major speaking driver program

PROGRAMMER: Steven Entine

DATE: January 16, 1976

K?

This program requires data in variable on what to spead. XX is a string valued variable that may contain English words, numeric data, or times of the day. These are separated by one space. The routing can also accept pointers to a global containing the octal. This is flagged by replacing a word that would normally appear in XX by the two pointers to the global preceded by a # sign. Hence, rather than the word "hello" one could replace it with "#34,1290". While this looks unreadable it will execute much faster. Pointers and English may be interspersed at will. In addition to XX other variable may be defined.

1) ANS - if defined an answer is desired from the user and the answer is to be placed in the variable whose name is in ANS. Hence, ANS should be a string of 1,2, or 3 letters.

2) END - if defined the output should be spoken immediately and the buffer in the Votrax Synthesizer should be cleared.

3) DBG - if defined a user is debugging a program from a terminal. English, as well as the phonems, will appear as output. This cannot be used with the current PDP-8 programs. It is strictly for debugging purposes. If DBG = "QUI" only English (no phonems) will be printed.

In addition to these, the routine also uses variables BB, BBB, BC and many variables preceded by a % sign. The calling programs should not use these variables.

Program VSP is used to signal the end of the string to the speaking routines and to prompt the PDP-8 to wait for an answer if one is needed, or empty the buffer if that has been specified. It calls VOZ for all actual speaking. This routine also checks if user's input has been a "*7" to signal repeating. If this is the case routine calls program VSS to repeat a message. The routine always kills variable ANS and GND.

PROGRAMS USED: VOZ VSS

GLOBALS USED: CVS

Votrax Synthetic Voice Response on PDP-15 System

TITLE: VOZ

PURPOSE: This program actually will speak the text in variable XX

PROGRAMMER: Steven Entine

DATE: January 16,1976

The program will break XX into individual words, numbers, or pointers. These are separated by a space. For each of these, VOZ will determine if it is a word- in which case it will find it in the dictionary and speak it; a number- in which case program VON is called to speak it; a time- which also uses VON: or a direct pointer into the global.

In case of words, the word is hashed according to the dictionary storage format, and an attempt is made to find it in global VVW. This global contains a list of all global words in the dictionary. If it is successfully found, the corresponding node of global VVO has the necessary phonemes to speak. These are spoken and are also stored in global CVS for recall if the user requests the message to be repeated. If the word is not found in global VVW, then nothing is spoken. However, it is tagged and logged in global ZOT for later use. A listing of all words in ZOT can be printed out. A decision can be made if these should indee be added to the dictionary.

In the case of direct pointers into the global, the appropriate node of global VVO is sent to the PDP-8 for speaking and also logged into CVS for repeating. No search in the dictionary is necessary nor are any checks made to assure that this word really does exist. It is the user's responsibility when using pointers to be sure that the node is in fact in the dictionary.

This routine and routine VON use variable BB to keep track of the number of phonemes that have been sent out in this buffer. If this number is greater than the threshold (usually 80), a signal is sent to the PDP-8 to speak this buffer and propare for input for the next buffer. The Votrax cannot handle more than one buffer of speach at a time and blockin is taken care of in routines VOZ and VON. If variable DBG is defined the this routine will print out the English as well as the phonemes. When it is sending messages to the PDP-8 to clear a buffer this is als shown at the terminal.

PROGRAMS USED: VON

GLOBALS USED: CVS, VVO, VVW, ZOT

Votrax Synthetic Voice Response on PDP-15 System

TITLE:_ VON

PURPOSE: Speak numbers and time

PROGRAMMER: Steven Entine

DATE: January 16,1976

This program is called by VOZ to speak numeric data and times of the day. It will automatically translate numbers of the form "1234" and speak them as "one thousand two hundred thirty four". It can do this for numbers up to nine hundred ninety nine thousand, nine hundred and ninety nine point ninety nine. For numbers greater than one million the digits are spoken one at a time. For digits to the right of the decimal point, if there are three or fewer they are spoken one digittat a time. Leading zeros are always spoken for numbers to the right of the decimal point.

Times are signaled by having a colon in them. In this case all numbers are always spoken so that 12:06 will speak as twelve 0 six. The variable BB is used to be compatible with VOZ in assuring that the Votrax buffer is not over filled. It also places all variables spoken into global CVS for repeating. If variable DBG is defined, then the numbers that are spoken are also printed on the terminal.

PROGRAMS USED: None

GLOBALS USED: VO, CVS

Votrax Synthetic Voice Response on PDP-15 System

TITLE: VSS

PURPOSE: Repeat last message spoken

PROGRAMMER: Steven Entine

DATE: January 16, 1976

VSS Called only when a user responds to a prompt for input with "*7". It will repeat all words spoken by the Votrax up to the user's previous input. It does this by using global CVS where the phonems have been temporarily stored, rather than reconstructing from the basic dictionary. For this reason repeated messages should be heard much quicker than messages the first time. There should be no apparent lag in response time.

PROGRAMS USED: None

GLOBALS USED: CVS

Storing Words for the Voice Response System

We need a program to allow permanent disk storage for new words. These will be used by the Votrax voice response system. Each word is stored in three forms:

a. The usual english spelling
b. A list of 'phonemes'. This will be constructed using the PDP-8 dictionary program. (This dictionary program runs independently of the PDP-15)
c. In an 'octal' format for use by the votrax synthesizer.

There are utility routines which will translate phonemes into the octal and store the information in the dictionary. What is needed is a program to allow a user to type in the english word and the corresponding phonemes, edit them as needed, verify that they are correct and should be stored permanently, and then call existing programs to do the translation and actual storage.

An example of the three types of storage is:

a. FIELD
b. 1pa0 2f 2ie 1iy iuh3 iL id
c. HCMMOLJIJCIHIN

You will only have to be concerned with types a and b. I have a separate list of legal phonemes. Each is a number (from 1-3) followed by 1-3 alphanumeric characters. Your program should be done in password FPS. Its ID should be VAH. You should not use any globals.

The user should be allowed to enter the english and the phonemes. They should be able to re-enter the english and edit (by deleting, adding,or replacing a single phoneme) the corresponding phonemes. They should then be able to certify the combination for st or declare the entry as garbage.

Once you have a certified entry, you should place the english into variable 'Y' and the phonemes into variable 'X'. SPACES and punctuation are crucial. The english can NOT have ANY spaces. If someone wants to store 'GOOD MORNING', it should be done as 2 separate entries. Phonemes should have EXACTLY one space separating them. Thus, in the above example, you should have code that would accomplish:

Y="FIELD" X="1pa0 2f 2ie 1iy iuh3 i1 id"

Then CALL VAE. This will code the phonemes into the octal and store the word in the permanant voice dictionary. If the word already exists, the user will be given a warnir message and asked if this entry is to replace the old one. If an illegal phoneme is passed to this routine, a message will be given and the word will be ignored.

To check if a word was properly stored, you can use program VAC. This will ask you for a word. If it is not in the dictionary, you will be so informed. If it is, it will print the indices in the global, the phonemes, and the octal. There are also programs to delete a word or to create a duplicate (the later is useful for abbreviations or homonyms.)

Storing and changing voice dictionary words in the PDP-15

We need a program to allow the addition and correction of words in the voice vocal It should be program CVW in password FPS. (If you need more 'ID's, use CVU,CVR)

Each word is s ored in three forms:

a. The usual english spelling
b. Phonemes used by people to create and edit the spoken word.
c. Phonemes used by the PDP-8 and Votrax to actually speak the word.

The user will key in versions a and b. Using version b and the folloiwing algorit the program must compute version 'c'.

Example: The english word FIELD (type 'a') has phonemes
1pa0 2f 2ie 1iy iuh3 1L 1d (type 'b')
and the votrax uses HCMMOLJIJCIHIN

Note the following: The phonemes used by people are ALWAYS 1 number followed by one to three other characters. Each of these corresponds to TWO letters in the phoneme used by the votrax. There are 256 possible phonemes.

I have a table listing the corrsponding OCTAL numeric value for each basic phonem By a basic phoneme, I mean the characters that follow the number. The number is f an 'accent' flag.

Example: pao is 03_8

f is 35_8

ie is 74_8

To these basic values, we use the following offsets for the accent.
For a '1', procced the value with 2. For a '2', preceed the value with 3. For a '3', preceed the value with a '0'.

Thus 1pa0 is 203_8; 2f is 335_8; 2ie is 274_8;

3ie would be 074_8.

This will always represent 8 binary bits. It will be 3 octal numbers but the firs will never be 4 or more. Separate this into 2 numbers of 4 bits each.
Thus 1pao is 203_8 or as a binary number it is 10000011_2
Separated into two numbers we get: 1000 0011
Convert these two binary numbers into a decimal number 83.
Now, convert these into the corresponding letter of the alphabetic HC.

Example 2: f=35_8 so 2f is 335_8=11011101_2=1101 1101=13_{10} 13_{10}=MM

Example 3: ie=74_8 ;2ie=374_8=11111100=1111 1100= 15 12= OL